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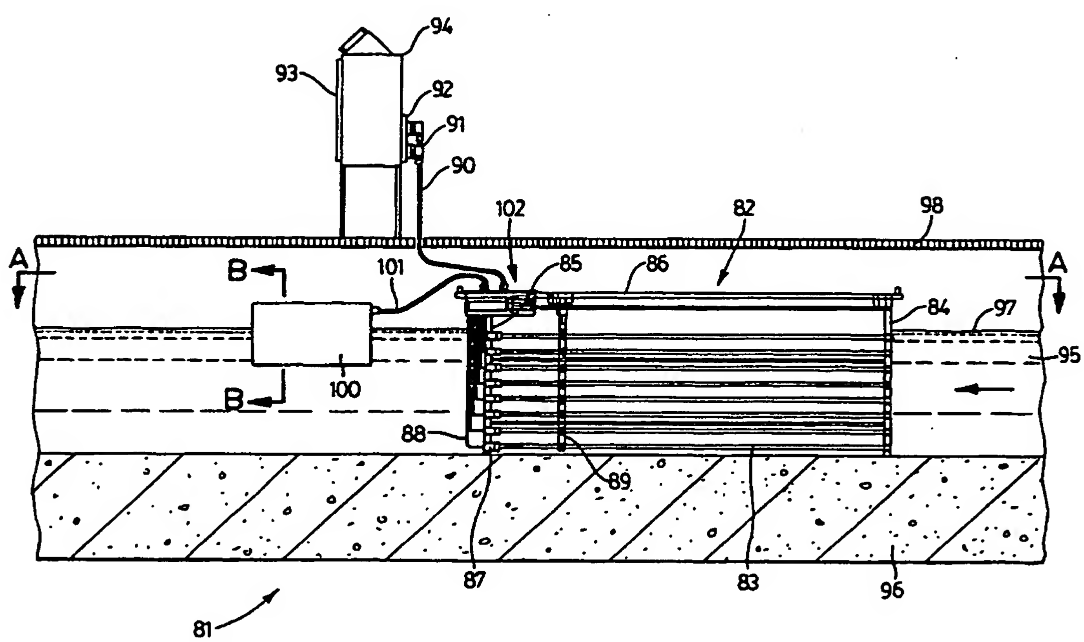
(54) Title: COOLING OF BALLAST IN WATER PURIFICATION APPARATUS



(57) Abstract: A water purification apparatus having a plurality of lamp assemblies and a floating ballast. Each lamp assembly comprises an elongate ultraviolet lamp having a protective sheath thereon. The lamp assemblies are in a parallel spaced-apart relationship and adapted to be submerged in the water. Each of the lamp assemblies is connected to a source of electricity, which includes a ballast. The ballast is located in water-proof container therefor that is adapted to float on the water. The water effects cooling of the ballast.

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TITLE

COOLING OF BALLAST IN WATER PURIFICATION APPARATUS

Field of the Invention

The present invention relates to apparatus for the purification or disinfection of fluid, especially water, using ultraviolet light, and particularly to the cooling of the ballast that is used in such apparatus.

Background to the Invention

It is well known to treat water, particularly wastewater, with ultraviolet light in order to effect a purification or disinfection of the water so that it is suitable for discharge into a lake, river or stream or so that the water is potable water and suitable for consumption.

The ultraviolet treatment systems use lamps with ballasts in order to produce the ultraviolet (UV) light. The ultraviolet treatment system typically has a plurality of elongated ultraviolet lamps arranged in a parallel space-apart relationship and supported in a frame. Racks of ultraviolet lamps in a frame are placed in a channel through which the water is passed, with the lamps being located underwater. The lamps are enclosed in a sheath typically formed of quartz. Each ballast will typically operate one or two lamps. Thus, the number of ballasts in an ultraviolet treatment system may vary from one to tens of thousands.

Ballasts produce heat during use, regardless of whether they are an electronic or an older core-coil style ballast. The cooling of the ballast is important to the operation of the system, as the higher the operating temperature of the ballast, the shorter the lifetime of the ballast. Thus, the dissipation of heat from the ballast is a major draw back to the use of ultraviolet treatment systems for the disinfection of water and wastewater.

A variety of methods may be used to dissipate the heat. For example, the heat from the ballast may be dissipated using fans, or an air conditioner may be attached to the system. In some instances, the ultraviolet treatment

systems may be placed in air-conditioned buildings. Cooling lines may be passed through containers holding the ballast. It will be appreciated that air conditioners and cooling systems are costly to operate.

Alternatively, the ballast may be placed on top of the frame containing the ultraviolet lamps, to spread out the positioning of the ballasts and to facilitate dissipation of heat. However, in hot climates and areas with a lot of sunlight, ballasts that are placed on the top of the ultraviolet lamp frames may overheat, and buildings with air conditioners or sun shields may be required.

Filters on fans or air conditioners used in the cooling of ballasts are very susceptible to the accumulation of insects and dust, which tend to plug the filters and restrict the flow of air through the filters. Consequently, the ballasts tend to overheat. To prevent overheating, costly monitoring systems, maintenance and backup ultraviolet treatment systems are required.

Wastewater treatment plants are usually built in low-lying areas, to reduce the cost of pumping of sewage to higher elevations. The treated wastewater is often emptied into a body of water e.g. a lake or river. Thus, in some instances, the ultraviolet treatment plant may be on a flood plain, and subjected to periodic flooding as a result of the location of the plant. It may, therefore, be necessary to seek to waterproof the ultraviolet treatment system and cool the ballast at the same time, which can lead to complex ultraviolet treatment systems.

The ability of an ultraviolet light treatment system to inactivate micro-organisms is a function of the UV fluence generated in the treatment system. The UV fluence is the product of the fluence rate and the time. The ability of ultraviolet light to penetrate wastewater, and hence treat the wastewater, is affected by the UV transmission. As the ultraviolet transmission from the lamp decreases, the fluence rate also decreases. Thus, for a particular ultraviolet lamp, the important factors in the transmission of ultraviolet light include the age of the lamp, the degree of fouling of the lamps i.e. the degree of fouling of the quartz sleeve on the lamp, and the clarity of the wastewater that is being treated.

Steps may be taken to clean the lamps and especially the quartz sleeve on the lamp. These steps are typically carried out on a periodic basis using scrapers or other techniques. This may be done on a daily basis or more or less frequently, depending on the quality of the water.

The clarity of the water to be treated may be difficult or impossible to control. In addition, the amount of ultraviolet light obtainable from an ultraviolet lamp is limited. Thus, the consequence of the need to provide a UV fluence to efficiently and effectively treat the water is that there is a tendency and desire to place the ultraviolet lamps closer and closer together and/or to use more ultraviolet lamps. This tends to result in a headloss of water flowing through the treatment system. The cross-section of the ultraviolet lamps and their protective sleeves must be minimized in order to reduce the headloss. Structural components of the rack of ultraviolet lamps are also a factor. If the ballasts are placed under water in-line and next to the ultraviolet lamps on the rack, as is known, the ballast becomes a major limiting factor in the placement of the lamps closer together. If the ballasts are placed on top of the racks of ultraviolet lamps, a limiting factor for placing the lamps closer together is the size of the ballast and the need to provide adequate cooling.

The re-positioning of ballasts to enable the lamps to be moved closer together, without the need to use expensive and complicated air-conditioning and cooling systems, would lead to the ability to provide more economical ultraviolet treatment systems with higher UV fluence rate. Such systems would be useful in the treatment of wastewater.

Summary of the invention

An ultraviolet light treatment system that utilizes a floating ballast has now been found.

Accordingly, the present invention provides a water purification apparatus comprising a water purification device comprising, in combination, a plurality of lamp assemblies, each said lamp assembly comprising an elongate ultraviolet lamp having a protective sheath thereon, the lamp assemblies being in a parallel spaced-apart relationship and adapted to be

submerged in said water, each of said lamp assemblies being connected to a source of electricity, said source including a ballast, said ballast being located in a water-proof container therefor that is adapted to float on said water, said water effecting cooling of said ballast.

In a preferred embodiment of the present invention, the ballast box is fabricated from a material that is resistant to ultraviolet light and an effective conductor of heat, especially from a material is selected from the group consisting of stainless steel and marine-grade aluminium.

In another embodiment, the water-proof container has external fins for dissipation of heat.

In further embodiments, the lamp assembly is connected to the ballast by one electrical cable, or each lamp of the lamp assembly is connected to the ballast box by an electrical cable.

In other embodiments, the ballast box is anchored to the lamp assembly, for example by a chain or by a connecting rod.

In further embodiments, there are a plurality of lamp assemblies, each lamp assembly having a floating water-proof container with said ballast.

A further aspect of the present invention provides a method for the cooling of a ballast in a water purification apparatus, said apparatus comprising a plurality of lamp assemblies, each said lamp assembly comprising an elongate ultraviolet lamp having a protective sheath thereon, the lamp assemblies being in a parallel spaced-apart relationship and being submerged in said water, each of said lamp assemblies being connected to a source of electricity that includes a ballast, said method comprising locating said ballast in a water-proof container, floating said container on the water to be purified and thereby effecting cooling of said ballast.

Brief Description of the Drawings

The present invention is illustrated by the embodiments shown in the drawings in which:

Fig. 1 is a schematic representation of an ultraviolet light treatment system of the prior art, in which the ballast is cooled by fans;

Fig. 2 is schematic representation of an ultraviolet light treatment system of the prior art, in which the ballasts are located on the racks of the treatment system, above water;

Fig. 3 is a schematic representation of an ultraviolet light treatment system of the prior art, in which the ballasts are located above the racks;

Fig. 4 is a schematic representation of an ultraviolet light treatment system of the prior art, in which the ballasts are located under water in-line with the lamps;

Fig. 4A is a schematic representation of a cross-section of the ultraviolet light treatment system of Fig. 4, through A-A;

Fig. 5 is a schematic representation of an ultraviolet light treatment system of the present invention, in which the ballasts are floating;

Fig.s 5A and 5B are schematic representations of cross-sections of the apparatus of the ultraviolet light treatment system of Fig. 5, through A-A and B-B, respectively;

Fig. 6 is a schematic representation of an alternate embodiment of the ultraviolet light system of the present invention; and

Fig. 6A is a schematic representation of a further embodiment of the ultraviolet light system of the present invention.

Detailed Description of the Invention

Fig. 1 shows apparatus 1 of one embodiment of an ultraviolet treatment system of the prior art. Apparatus 1 has a plurality of elongated ultraviolet lamps 2 formed in an array of lamps in a parallel and spaced apart relationship. Lamps 2 are supported by rack 3. In Fig. 1, three assemblies of lamps 4A, 4B and 4C are shown. The assemblies of lamps 4A–4C are located in channel 5, and are shown as resting on channel base 6. Channel 5 is covered by grate 7. The water level in channel 5 is controlled by level controlled gate 8. Level probe 11 is used to monitor the water level and to turn off the lamps if the water drops and the uppermost layer of lamps is exposed to the air.

Three control panels, 9A, 9B and 9C are located above grate 7. Each of control panels 9A-9C is connected to the respective assembly of lamps 4A-4C, and is used in the control and operation of the lamps. The ballasts required in the system are located within control panels 9A-9C. Each of control panels 9A-9C has a fan 10, for the cooling of the control panel and in particular for the cooling of the ballasts.

In operation, water flows through channel 5 in the direction indicated by the arrow. The level of the water is controlled by level control gate 8. Ultraviolet lamps 2 are controlled using control panel 9. During operation of the apparatus 1, the ballasts located within control panels 9A-9C generate heat and must be cooled. The heat must be dissipated. In the embodiment of the prior art illustrated in Fig. 1, the cooling of the ballasts is accomplished using fan 10.

An example of the prior art illustrated in Fig. 1 is shown in U.S. Patent 4 482 809.

Fig. 2 shows apparatus 21 of a second embodiment of the prior art. Apparatus 21 has ultraviolet lamps 22 formed in assemblies of lamps 23A-23C located in channel 24. Channel 24 has level control gate 25 which maintains the water at water level 26. Intake 29 has slide gate 27 which controls the flow of water into channel 24. The water level of intake 29 is shown as intake water level 28. Stilling plate 30 is located in channel 24 between slide gate 27 and the first assembly of lamps, 23A. Control panels 33A-33C are associated with each of assemblies of lamps 23A-23C.

A drain 35 is provided in channel 24. The water level in outlet 31 is indicated as outlet water level 32. Each control panel 33 and assembly of lamps 23 has ballasts associated therewith, being 34A-34C. The ballasts 34A-34C are located above water level 26. In each instance, the respective ballasts 34 are located on the assembly of lamps 23, and are cooled by convection.

The direction of the flow of water through the apparatus is indicated by the arrows.

An example of the prior art illustrated in Fig. 2 is shown in U.S. Patent 4 872 980.

Fig. 3 shows apparatus 41 of a third embodiment of the prior art. Apparatus 41 has an assembly of lamps 42A-42F, in which the lamps are arranged in a vertical orientation. The assemblies of lamps 42-42F are located in channel 43. The water level 44 of channel 43 is indicated. Water passes from inlet 45 through channel 43 to outlet 46. The water level 44 is controlled by level control gate 47. Control panel 48 is used in the control of the ultraviolet light treatment system and is connected (not shown) to each of ballast containers 49A-49F. Each assembly of lamps 42 has a ballast container 49 associated therewith. In addition, each of ballast containers 49 has a fan (not shown) associated therewith for the cooling of the ballast.

An example of the prior art illustrated in Fig. 3 is shown in US Patent 5 660 719.

Fig. 4 shows an LPX-200 ultraviolet disinfection system, which is a further embodiment of the prior art. Apparatus 61 has assemblies of lamps 62A-62B. Assembly of lamps 62A has ballast 63A and wiper mechanism 64A. Assembly of lamps 62B is of the same construction. Water level 66 in channel 67 is controlled by level control gate 65. In addition, channel 67 has inlet gate 68. Control panel 69A and 69B are connected by cable 70A and 70B to the respective assembly of lamps 62A and 62B.

In the embodiment of Figure 4, both the ballast and the lamps are located under water. Thus, in this embodiment the water flowing through channel 67 effects the cooling of ballast 63A and 63B.

A cross section of Figure 4 through A-A is shown in Fig. 4A. In Fig. 4A, four assemblies of lamps 62 are shown in a side-by-side relationship. Thus, it is apparent that each assembly of lamps 62 has the plurality of horizontal lamps stacked in a vertical arrangement as shown in Fig. 4 as well as the four assemblies of lamps shown in Fig. 4A. The assemblies of lamps 62 are located in channel 67 below water level 66. Each assembly of lamps 62 is connected by respective cables 70 through control panel 69. It will be

apparent that the assembly of lamps 62 forms a substantial portion of the cross section of channel 67.

Fig. 5 shows an embodiment of the apparatus of the present invention. Apparatus 81 has an assembly of lamps, generally indicated by 82. Assembly of lamps 82 has a plurality of lamps 83 that are located in a spaced-apart horizontal position. Although Fig. 5 shows the lamps in a horizontal position, which is preferred, the lamps may also be used in a vertical position, similar to that illustrated in Fig. 3. Lamps 83 extend between first rack end 84 and second rack end 85, which support lamps 83. First rack end 84 and second rack end 85 form part of frame 86. Each lamp 83 has connector 87 at second rack end 85, and is then connected to electrical conduit 88. Lamp assembly 82 is shown with wiper mechanism 89.

Multi-conductor cables 90 extend from assembly 82 to lamp rack connector 91. Lamp rack connector 91 is located on rear access door 92 of control panel 94. Control panel 94 also has front access door 93. Control panel 94 may also be referred to as a power distribution center.

Assembly 82 is located in channel 95. Channel 95 has channel base 96 and grid 98. Control panel 94 is located adjacent to grid 98, and is supported by walls (not shown) of channel 95. Channel 95 has a water level 97 that is controlled by means that are not shown.

Ballast box 100 is shown as floating in the water of channel 95. Ballast box 100 has ballast cable 101 that extends to electrical panel 102. Multi-conductor cable 90 from control panel 94 is also connected to electrical panel 102, and is in turn connected through electrical conduits 88 to each of lamps 83.

In the present invention, the ballasts for the assembly of lamps are located in ballast box 100. Ballast box 100, which should have a water-tight seal, floats on the water within channel 95. Thus, the ballasts are cooled by the water in channel 95, and fans, air conditioning or other cooling means are not required. In addition, the ballasts are not located under water in channel 95, as shown in Fig. 4, where they could impede flow of water through channel 95 and/or cause a head loss of water. The ballasts are not located

above the assembly of lamps e.g. on a grid extending over the lamps where cooling of the ballasts requires that the ballasts be separated by sufficient distance to effect cooling and/or installation of cooling facilities.

The length of ballast cable 101 may be varied. It could be a relatively short cable, as illustrated, or a longer cable. A short cable should be of sufficient length to permit removal of ballast box 100 from the water for cleaning or for any other reason e.g. when channel 95 is emptied. A longer cable could permit ballast box 100 to rest on channel base 96 when channel 95 is emptied.

The present invention is illustrated by the embodiment in which the floating ballast is tethered downstream of the lamp assemblies, by means of ballast cable 101. However, the floating ballast could be upstream of the lamp assemblies, and anchored so that it would not float into the lamp assemblies.

Fig. 5A shows a plan view of the apparatus of Fig. 5, along A-A. Ballast box 100 is connected to electrical panels 102 by ballast cables 101. In the embodiment shown, four ballast cables 101 are shown as extending from ballast box 100, one for each of lamp assemblies 82, and there are correspondingly four ballasts located in ballast box 100, as shown in Fig. 5B. Each ballast cable 101 is connected to a electrical panel 102. Four assemblies of lamps 82 are shown, each of which is connected to the corresponding electrical panel 102. It will be noted that the assemblies of lamps 82 occupy the full width of channel 95, so that water passing through channel 95 is subjected to ultraviolet light generated by the assemblies of lamps 82 at an acceptable UV fluence rate.

Fig. 5B is a cross-section of ballast box 100, through B-B. Ballast box 100 is shown as containing four ballasts 103, each of which is connected to a ballast cable 101 (not shown). Ballast box 100 is shown as having a lid 104, sides 105 and bottom 106. Sides 105 and bottom 106 are shown as having fins on their outer surface to maximize surface area of the sides and bottom and thus increase the rate of cooling of the ballasts. It is understood that substantially all of sides 105 of ballast box 100 are beneath the surface of the

water that is being treated. Such water is flowing over the surface of sides 105 and bottom 106 during normal use.

Fig. 5B shows four ballasts located on the bottom of the ballast box. Ballasts may also be located on the sides of the ballast box. In addition, the ballasts may be positioned on a heat sink material attached to the sides and/or bottom of the ballast box, to enhance the cooling of the ballasts.

Fig. 6 shows another embodiment of the ultraviolet light treatment system of the present invention. The embodiment of Fig. 6 differs from the embodiment of Fig. 5 in that ballast cable 101 extending from ballast box 100 to electrical panel 102 has been replaced with a plurality of individual ballast cables 110. Each lamp connector 87 of lamps 83 is connected to ballast box 100 by a separate ballast cable 110. Thus, for each lamp 83, ballast cable 110 may be replaced without a need to fully dismantle the apparatus of the system, thereby permitting rapid replacement of cables if it is necessary to do so.

Fig. 6 also shows multi-conductor cable 90 as being separate cables 90A to ballast box 100, where the separate cables would be attached to separate ballast boxes. In this manner, a group of ballast boxes would be used with one ballast box for each rack of lamps, as distinct from an embodiment with one ballast box for all of the assembly of lamps in one channel. This would permit individual ballasts and/or cables to or from the ballasts and/or ballast boxes to be replaced, if necessary, rather than a need to shut down the entire system in order to replace ballasts or cables. Another variation of the embodiment of Fig. 6 is shown in Fig. 6A.. Thus, it will be appreciated that in various embodiments of the invention, one ballast may be used or multiple ballasts may be used, and that multiple ballasts may have multiple cables from a control panel, and that there may be a single cable or multiple cables to assemblies or racks of lamps. This permits many variations in versatility of connections of control panel to ballast(s) and of ballast(s) to lamps.

Consequently, with the floating ballast and in various embodiments of the present invention, including the embodiments of Fig.s 5, 6 and 6A, there

can be substantial flexibility to effect replacement of parts in the system without the need to fully dismantle the lamp assembly and associated ballast system. This reduces the down-time if parts of the system must be replaced, including replaced in preventative maintenance of the system.

The ballast box may be fabricated out of a variety of materials, but such materials need to be resistant to both ultraviolet light and to the water in which the box floats. Preferred materials are both resistant to ultraviolet light and are effective conductors of heat. The materials may be coated to provide additional protection against ultraviolet light. Examples of the materials include stainless steel and marine-grade aluminum.

In Fig.s 5 and 6, the ballast box is shown as being connected to the lamps assembly by ballast cables 101 or 110. However, it is to be understood that it is preferred that a chain, 111, be attached between ballast box 100 and the assembly of lamps, for relief of strain that might be imposed on the cable as a consequence of the flow of water in channel 95. The chain would be of a length that is shorter than the ballast cables, so that strain is not imposed onto the cables. A pivotable connecting rod may be used in place of or in addition to the chain, with or without electrical connections e.g. ballast cables, in or attached to the rod. If the rod and chain are used, the chain would be a safety chain.

The present invention provides a simple method for the cooling of the ballast required for the lamps. The ballasts are conveniently located with respect to the position of the lamps. The ballasts do not require expensive cooling systems located on or above a grid above the channel of water, where their physical location may impede movement on the grid and/or repair and cleaning of lamps. One ballast box may be used for all lamps of an assembly of lamps. Each lamp could have a separate connection to the ballast box, which would simplify any repair or maintenance. Fins on the ballast box may be used to increase dissipation of heat.

The present invention provides a simple and inexpensive method for the cooling of ballasts in an ultraviolet light treatment system. In addition, the

cooling of the ballast does not significantly affect the flow of water that is being treated.

CLAIMS:

1. A water purification apparatus comprising, in combination, a plurality of lamp assemblies, each said lamp assembly comprising an elongate ultraviolet lamp having a protective sheath thereon, the lamp assemblies being in a parallel spaced-apart relationship and adapted to be submerged in said water, each of said lamp assemblies being connected to a source of electricity, said source including a ballast, said ballast being located in a water-proof container therefor that is adapted to float on said water, said water effecting cooling of said ballast.

2. The water purification apparatus of Claim 1 in which the ballast box is fabricated from a material that is resistant to ultraviolet light and an effective conductor of heat.

3. The water purification apparatus of Claim 2 in which the ballast box is fabricated from a material is selected from the group consisting of stainless steel and marine-grade aluminium.

4. The water purification apparatus of Claim 2 in which said water-proof container has external fins for dissipation of heat.

5. The water purification apparatus of Claim 2 in which the lamp assembly is connected to the ballast by one electrical cable.

6. The water purification apparatus of Claim 2 in which each lamp of the lamp assembly is connected to the ballast box by an electrical cable.

7. The water purification apparatus of Claim 2 in which the ballast box is anchored to the lamp assembly.

8. The water purification apparatus of Claim 7 in which the ballast box is

anchored to the lamp assembly by a chain.

9. The water purification apparatus of Claim 7 in which the ballast box is anchored to the lamp assembly by a connecting rod.

10. The water purification apparatus of Claim 9 in which the rod is pivotally attached.

11. The water purification apparatus of Claim 2 in which there are a plurality of lamp assemblies, each lamp assembly having a floating water-proof container with said ballast.

12. A method for the cooling of a ballast in a water purification apparatus, said apparatus comprising a plurality of lamp assemblies, each said lamp assembly comprising an elongate ultraviolet lamp having a protective sheath thereon, the lamp assemblies being in a parallel spaced-apart relationship and being submerged in said water, each of said lamp assemblies being connected to a source of electricity that includes a ballast, said method comprising locating said ballast in a water-proof container, floating said container on the water to be purified and thereby effecting cooling of said ballast.

13. The method of Claim 12 in which heat is dissipated from the ballast box by through external fins located on said box.

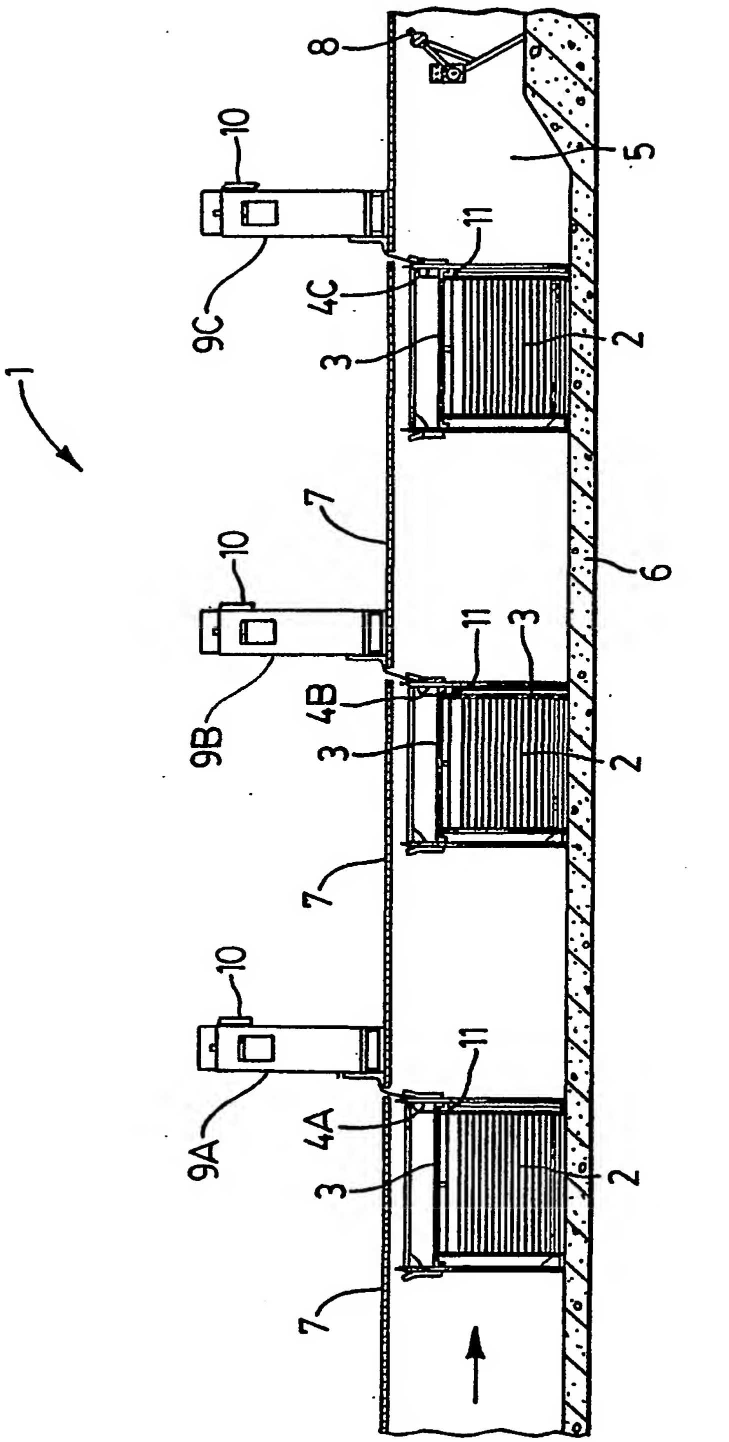

FIG. 1
(PRIOR ART)

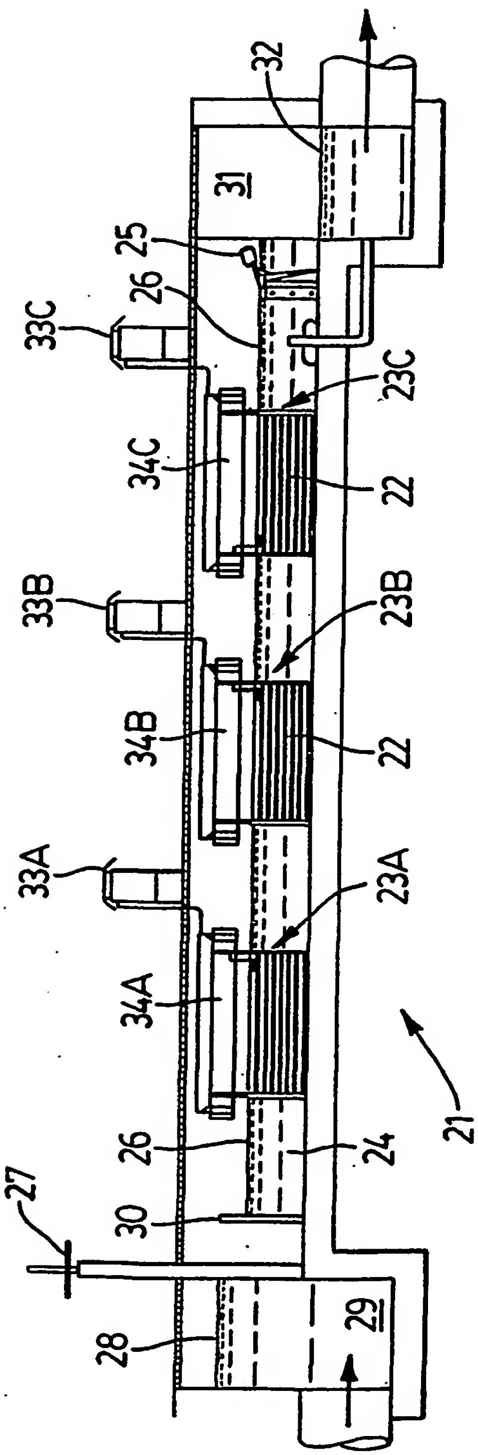

FIG. 2
(PRIOR ART)

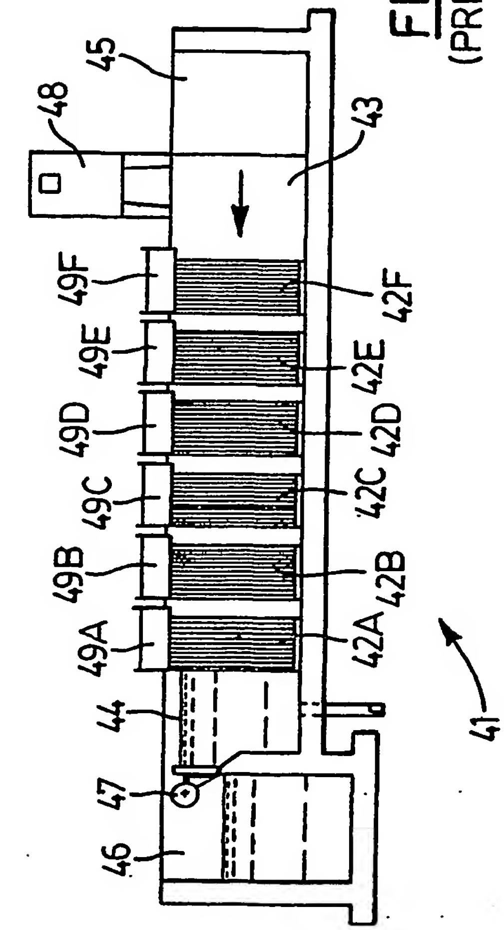

FIG. 3
(PRIOR ART)

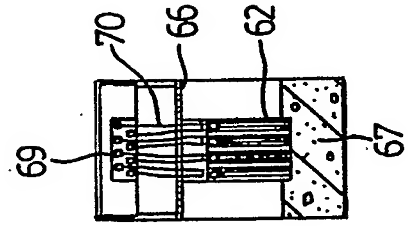

FIG. 4A
(PRIOR ART)

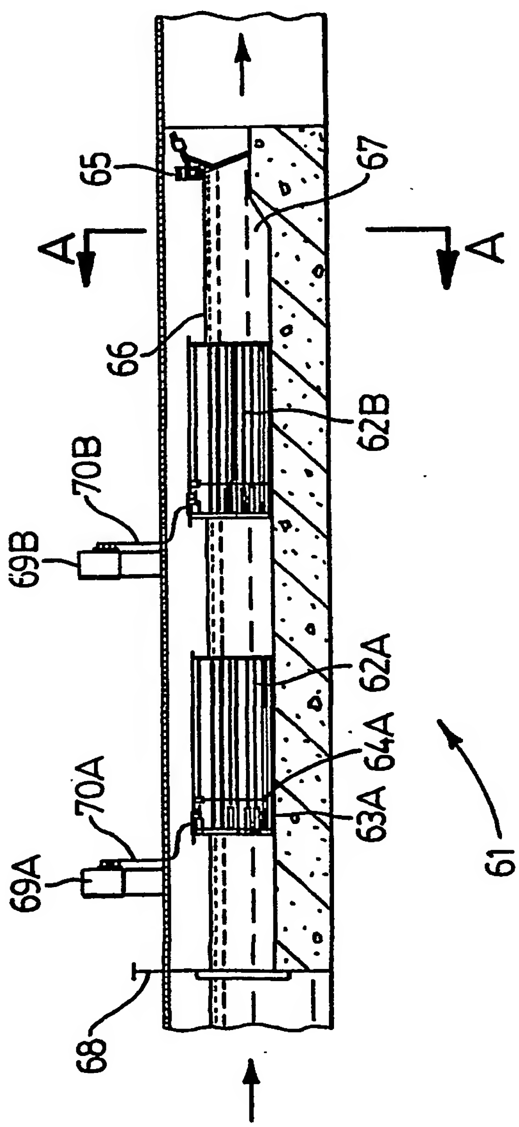

FIG. 4
(PRIOR ART)

4/7

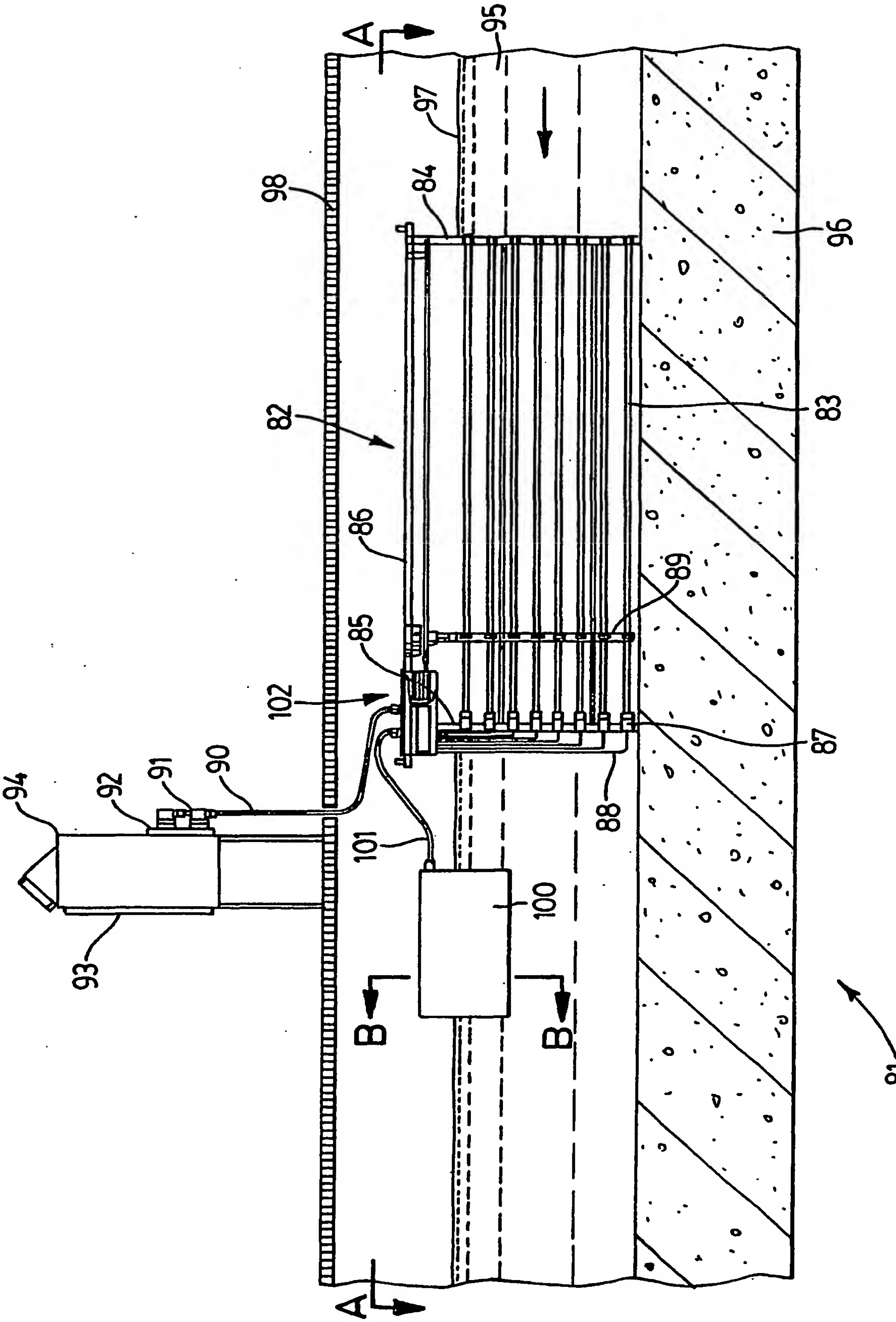

FIG. 5

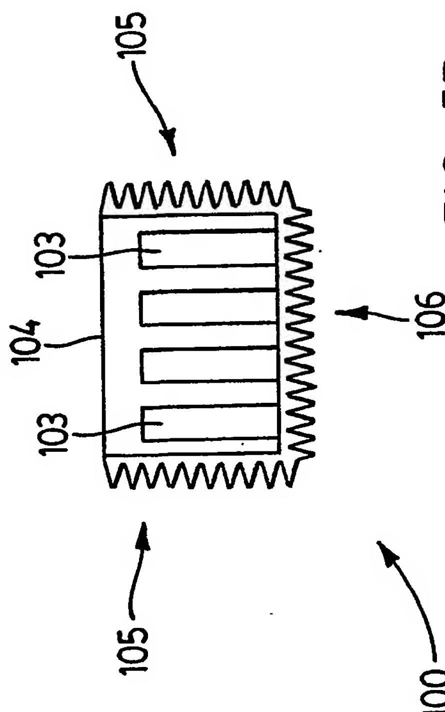

FIG. 5B

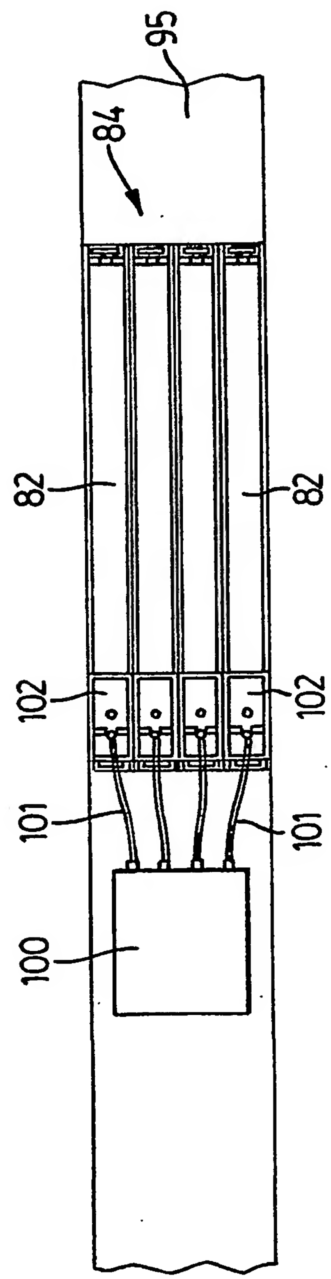

FIG. 5A

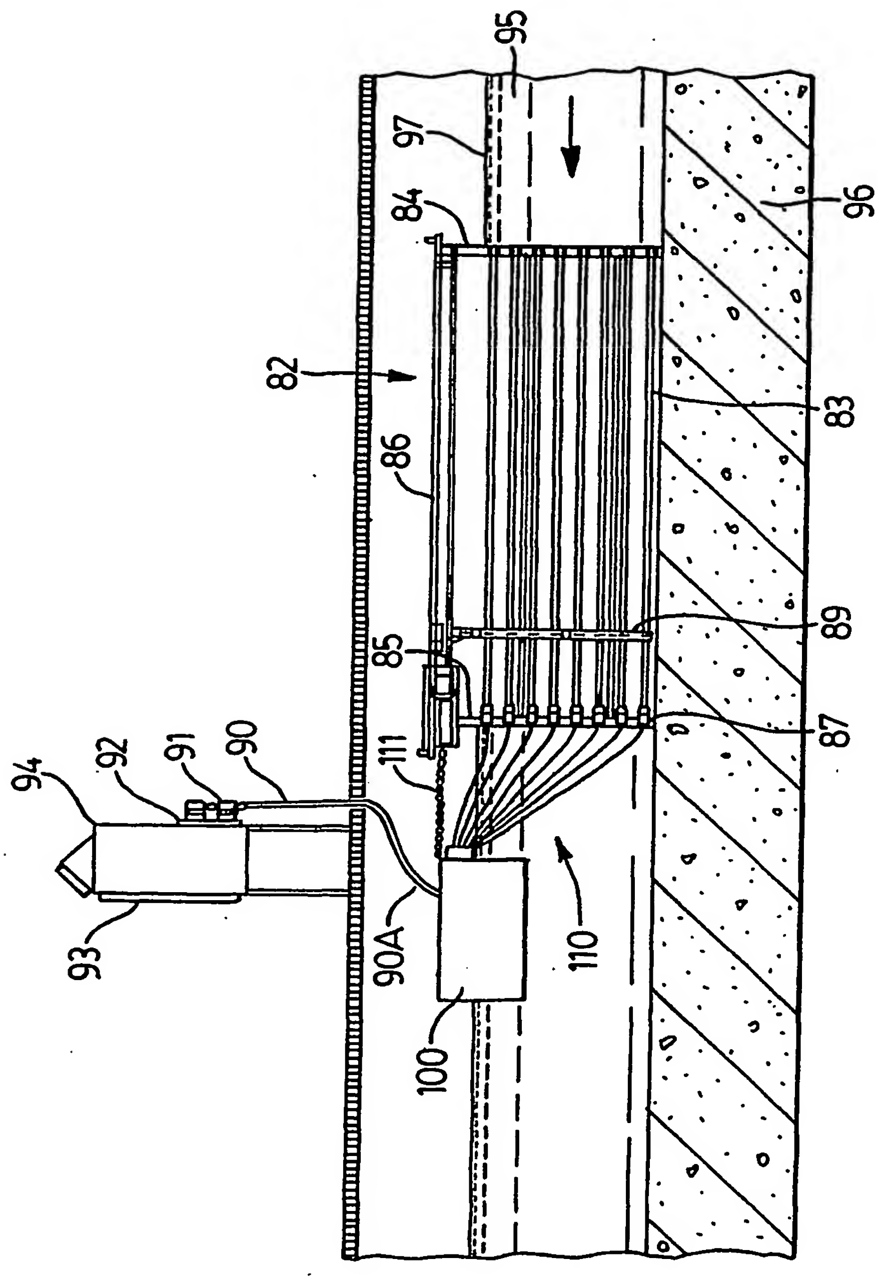

FIG. 6

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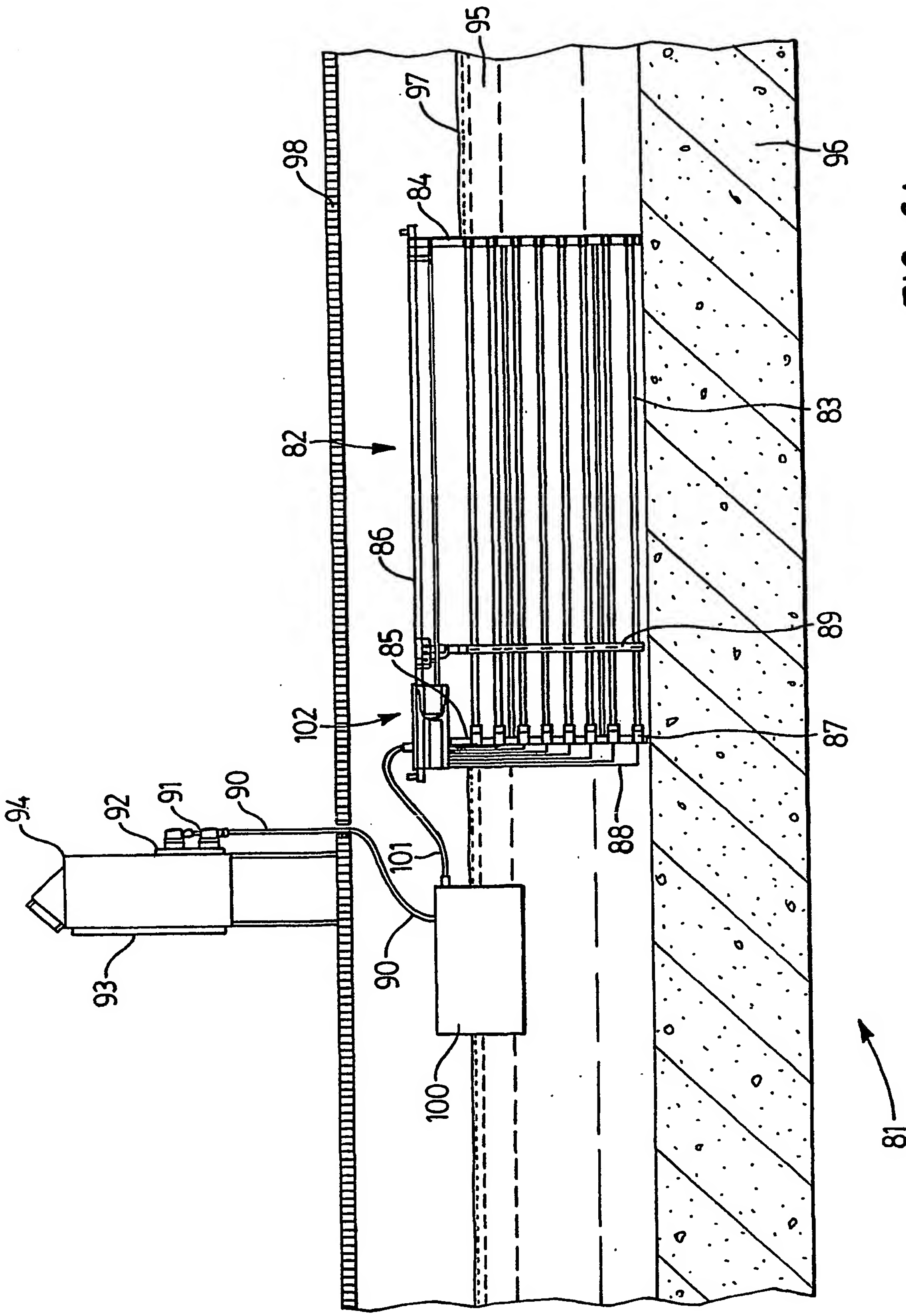

FIG. 6A

INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 00/01195

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C02F1/32 A61L2/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C02F A61L B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 019 256 A (IFILL LEE ET AL) 28 May 1991 (1991-05-28) column 6, line 62-64; figures 2,5	1-13
A	US 5 660 719 A (ALBERTAZZI PAUL ET AL) 26 August 1997 (1997-08-26) cited in the application figures	
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 09, 31 July 1998 (1998-07-31) & JP 10 085735 A (NIPPON PHOTO SCI:KK), 7 April 1998 (1998-04-07) abstract	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
9 July 2001	17/07/2001

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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